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A PHYSICAL ESSAY ON THE ANIMAL OECONOMY.

WHEREIN
The CIRCULATION of the BLOOD,
and its CAUSES are particularly conſider'd;

ALSO,
What Aſſiſtance the HEART and LUNGS
give thereto:

And This both from
ANATOMY and EXPERIMENTS.

To which are added,
Some Occaſional REFLECTIONS on Inflammatory
DISORDERS, and ſome Others which attend a
diſorder'd Circulation.

נפש הבשר בדם LEVIT. xvii. 11.

> "All Muſcles are furniſh'd with Blood-Veſſels and Nerves;
> "and their Action *depends* on the *Influx of Blood*, and of
> "the *Nervous Fluid*, into their muſcular Fibres."
>
> *Monro*'s ANATOMY.

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AN ESSAY ON THE ANIMAL OECONOMY.

HAVING found, from the general Opinion of phyſical Writers, that the Human Frame is a compleat Piece of Mechaniſm, and that to underſtand the mechanical Uſe of each Part muſt be of great Benefit both in Phyſick and Surgery; upon this Opinion I have endeavoured to ſearch out what are the principal Parts, and what their particular Uſes; and tho' ſome few Phyſicians may think Natural Philoſophy not at all concerned with Phyſick, or, at moſt, that a Man may be a good Phyſician without underſtanding any Part of it; yet, I doubt not but the conſiderate Part of the World, when they come to think, will then agree, that the Theory of Phyſick and Surgery is founded, and muſt be built upon *Anatomy*, *Philoſophy*, and *Mechanicks*, and that a tolerable Degree of Knowledge in all theſe Sciences is neceſſary to make a good Phyſician. This, I think, is a Fact which will not bear a Diſpute, except it is by thoſe that go on quite in an empiretical Way, without any

Regard to Theory at all; which indeed is the ſhorteſt and eaſieſt Way of attaining Knowledge in the Practice of Phyſick, and the Way every Apothecary's Apprentice gets his, I mean, if he is otherwiſe ſo idle and negligent as not to ſtudy nor uſe the proper Means in Order to underſtand the Theory of Phyſick; but whether it is the moſt reaſonable and beſt, or no, I ſhall leave others to determine; but ſhould think it neceſſary for a good Phyſician to have a tolerable Degree of Knowledge both of Theory, and of Practice, or Experience. I remember, *Rohault* (who is no deſpicable Author) gives his Opinion of this Matter in the following Words. " I could " not perſuade myſelf, ſays he, that the ſtudy " of natural Things was neglected, becauſe it " was thought to be of no Uſe; for Health " has always been eſteem'd one of the chief " Bleſſings of Life, and no one can be ignorant " that *Phyſick*, the ſole End of which is to " maintain and reſtore Health, *is built upon* " *Natural Philoſophy.* "This was alſo the Opinion of moſt of our greateſt Phyſicians. *Boerhaave* gives his Sentiments upon it thus: " A " ſlight Opinion of Mechanicks I take to be unbecoming a Phyſician, and the Source of many " Errors which he may be liable to in his Practice. We are convinced by attaining the " Knowledge of the peculiar Conſtruction of a " corporeal Machine, that the human Body is " of the ſame Nature with the whole Univerſe " of Things which we contemplate; and by the " Teſtimony of Senſe, and in the Judgment of

" Reaſon contains nothing extraordinary above
" the Reſt, if its Principle be ſeriouſly examin-
" ed, except that it conſiſts of more and diffe-
" rent Machines, *agitated by the Influx of Hu-*
" *mours*, to produce more Effects, and that great
" Variety of Motions, which, from the Laws of
" Mechanicks, flow from the Bulk, Figure, Soli-
" dity and Connexion of the Parts. Hence the
" human Body is a true mechanical Structure, and
" therefore poſſeſs'd of all the Properties which
" belong to a Subject the beſt qualified for me-
" chanical Speculation." After proving that the Knowledge of Mechanicks was neceſſary for a Phyſician he concludes thus: " All theſe Spe-
" cimens with infinitely more which might be
" brought, are enough to prove that almoſt all
" thoſe Things which either conſtitute or flow
" from Life and Health, *depend* on that *Motion*
" *by which the Humours move*, and act upon one
" another by a perfectly mutual Agitation, in
" their reſpective Veſſels, the Effects and Laws
" of which being rightly underſtood, explained
" and demonſtrated only by *Mechanicks*, under
" the Heads of *Hydraulicks* and *Pneumatichs*, I
" conclude again, that they are all the Subject
" of *Mechanicks*. From hence it muſt not be
" concluded, that we imagine every good Ma-
" thematician muſt be a Phyſician. No, on the
" contrary; but that there can be *no good Phyſi-*
" *cian that is not ſkilled in mechanic Learning*."

Hoffman tells us the Method of improving Phyſick is to be expected from the three following general Rules.

Firſt, "With the greateſt Attention and Diligence to write out full and accurate Accounts, "and Hiſtories of the ſeveral Diſeaſes which occur in Practice." *Secondly*, "By an attentive "and minute Diſſection to inveſtigate, as far as "poſſible, the curious and ſurpriſing Structure "of the Human Body." And, *Thirdly*, "By "the Aſſiſtance of *Experimental Philoſophy*, "which includes *Mechanicks* and *Chemiſtry*, to "ſearch for the hidden Cauſes which produce "particular Effects."

However as, I doubt not, but there will be always ſome who will ſtill go on in their empiretical Method of Practice, i. e. of giving themſelves no Trouble to attain the Knowledge of Anatomy, or the Parts of the Human Frame, with their Uſe; or to enquire why ſuch a Symptom attends ſuch a Diſorder. And, tho' they may be able to anſwer this to their own Conſciences, yet I will take upon me to give them one Piece of Advice, which is no more than has been obſerved, by that Father of Phyſick *Hippocrates*, viz. *always to endeavour to aſſiſt Nature in her Operations, but never to act in Contradiction thereto.* For the Human Frame is ſo wonderfully compoſed, that whenever any Part of it is diſorder'd, it generally points out the regular Method of Cure.—To make this appear clear, I ſhall give one of the moſt common Inſtances of it, viz. after taking Cold, and a Fever ſucceeding, the following Symptoms uſually ſucceed. A *Nauſea*, or Inclination to vomit, loathing of Food, Laſſitude, or an Inclination to Reſt, Thirſt, &c. *Accidents* by which the Perſons are often relieved are, bleeding at the Noſe, at the *Anus* by the Piles, &c. a *Diarrhœa*, or Purging. Now, all theſe are Efforts of Nature, known to point at the moſt regular, ſafe, and effectual Methods of removing an inflammatory Fever. All this the *Empirick* may have ſeen and known, but wants the Knowledge of the regular Phyſician, who makes it his Study, by Anatomy, and Natural Philoſophy, to underſtand the Make and Uſe of each Part of the human Frame; and from thence knows in what *Stadium* of the Diſorder to adminiſter Bleeding, Vomiting, Purging, &c. He knows that ſome Parts of the Blood being condenſed and thickned by taking Cold, are thereby made incapable to paſs the capillary Veſſels, whence Obſtructions muſt follow: Theſe Obſtructions by cauſing a Stoppage of the Pores of Perſpiration, and the Friction of the other Parts of the Blood againſt theſe Obſtructions, together with the continual Addition of Chyle, muſt ſoon increaſe its Heat; by theſe Means the Blood taking up more Space than it did before, the Circulation cannot regularly be carried on; therefore the firſt Thing to be done, muſt be by leſſening its Quantity by *Bleeding*, and thereby giving more Room for the Circulation to be carried on; *vomiting* and *abſtaining from Foods*, thereby preventing too great an Addition of Chyle; *Purging* to empty the inteſtinal Tube, and thereby leſſening the Reſiſtance that Way; whereby Nature will have it in her Power to throw off ſome of the offending Matter into the Guts, and from thence be carried off by Stool *.

Reſt, in theſe Caſes is always neceſſary, as it is known that the Friction occaſioned by Motion, muſt increaſe the Heat, and thereby expand the Blood, and make it take up a greater Space than it otherwiſe would.

Thirſt, or the Deſire of drinking plentifully, and often, of ſome ſmall diluting Liquid.—The Indulgence of this Appetite ſeems to be of ſuch Conſequence, that the obſtructing it makes all other Remedies, for the moſt Part, ineffectual; for, unleſs large Quantities of ſmall diluting Liquids are often taken by the Patient, it is not poſſible to open and waſh away the offending and obſtructing Matter.

I have been often ſurprized, and ſorry to ſee the *credulous Vulgar* ſo greatly impoſed upon by Perſons pretending to be *Adepts* in Phyſical Knowledge, when their whole Art conſiſted in a few empiretical Medicines. Theſe Impoſitions are the more to be lamented as they have occaſioned the Loſs of many Perſons Lives; a great many Inſtances of which I myſelf have ſeen; and the like may be often obſerved in the Small Pox in particular, in which Diſorder you will find many, and ſome of good Senſe and Capacity, to imagine that what they call a *good Nurſe*, is of more Conſequence towards the Life of the Patient than the Advice of the beſt Phyſician. As this is a Thing too generally received in ſome Places, I ſhall beg leave to make a Remark or two thereon.

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* That the Blood-Veſſels have a Paſſage into the Guts, has been made plainly to appear by the ingenious Mr. *Hale*, in his *Staticks*, vol. II. pag. 149. Who, by injecting Vermilion and Water into the Blood-Veſſels, with no greater Force than that of the circulating Blood, he found ſome of the Vermilion always came into the Cavity of the Guts.

I have in my own Practice known the Beginning and Riſe of many of theſe knowing and underſtanding Nurſes, moſt of which after they have ſeen *three or four* Perſons nurſed in the Small Pox, and have thereby been able to enquire for two or three empiretical Remedies have *then* ſet up for profeſs'd Nurſes, and pretended to underſtand this Diſorder better than thoſe Perſons who have made Phyſic their Study for many Years, joined with a long Experience.

Now, tho' one ſhould have imagined that a Caſe ſo plain as this is, would be ſeen thro' by all, even by thoſe whoſe Underſtanding is not the moſt clear; yet we daily ſee how theſe Creatures impoſe upon the *Credulous*, telling them what Cures they have perform'd on ſuch and ſuch Perſons, who, ſay they, had the Small Pox ſo bad that it was twenty-one Days before it turned.—Therefore as this and ſuch like Facts are entirely falſe, (and told either for want of knowing better, or elſe to impoſe on thoſe People they tell it to) I ſhall give a ſhort Hiſtory of this Diſorder, and then ſhew that the proper Methods of Cure are ſuch as Nature points out.

The Symptoms attending the firſt Stadium of the Small Pox, are cold Shiverings, Head and

Back Ach, Laſſitude, Thirſt, Nauſea and Vomiting.

Now, as it is obſerved amongſt the poorer Sort of People, where Nature is left to itſelf, that the later the Small Pox appear ſo much the more favourable will the Diſorder be, unleſs their Appearance is prevented by ſome violent Symptoms, viz. If they appear within the firſt twenty four Hours, or the firſt Day of Seiſure, they are mortal; if within the ſecond, extremely dangerous; if within the third, leſs ſo; but if on the fourth Day, or later, they are generally of the diſtinct Sort, and without Danger. So, knowing this from Experience and Obſervation, and ſtill remembering that general Rule, never to oppoſe nor contradict, but always to endeavour to aſſiſt Nature in her Operations, we muſt know that the proper Method in this *Stadium* muſt be as Nature directs; firſt to vomit; if the Patient is plethoric, to bleed, then give Plenty of opening diluting Liquids, thereby to empty the Stomach and Bowels, and alſo promote a gentle Perſpiration, and by that Means lowering the *Variolous*, or inflammatory Fever; whereby the Small Pox is retarded in its appearance. This Method ſhould be continued till the End of the ſixth Day from the Seiſure, about which Time they will be all out *.

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* The want of following the Dictates of Nature, in this Diſorder, but on the contrary giving hot Medicines in this *Stadium* of the Small Pox, (as is often the Method amongſt Nurſes) I am ſatisfied, has encreaſed the Fever ſo much as to be the Death of many Thouſands, as effectually as if they had taken Rat's-bane.

About the ſixth or ſeventh Day, after the Patient has had ſome ſmall Reſpite, comes on the Fever of Maturation. Now as it is well known that after an Inflammation or *Phlegmon* is arrived at ſuch a Height as not to be diſperſed, it muſt terminate either in Suppuration or Mortification; therefore, if the Patient is ſo far loaded with the Diſeaſe as to want Aſſiſtance from the Phyſician, the only proper Method to be uſed muſt be by giving ſuch Medicines as are known to aſſiſt Nature in order to carry on the Suppuration, and by that Means to prevent a Mortification *.

Having got thro' the *Stadium* of Maturation, which is generally finiſh'd about the twelfth or thirteenth Day, the next Thing to be adminiſter'd is a gentle Purge, which ſhould ſeldom or ever be delay'd beyond the thirteenth Day.— This is alſo pointed out by Nature, for Perſons who have it pretty favourable, and go thro' this Diſorder with little Aſſiſtance, have moſt com-

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* I here forbear mentioning any Medicine or *Recipe*, leſt Weapons ſhould be put in the Hands of Madmen; or at the beſt, in the Hands of thoſe who are ignorant how to uſe them. This I do, being well aſſured of the general Propenſity to *Empiriciſm*, or the Uſe of Quack Medicines, and that the good Effects of Medicines rather ariſe and take their Force from the *Judgment of the Phyſician*, in their juſt Application, than from any Virtues *inherent* in themſelves; for the greater the real Virtue any Medicine has, the worſe will be its Effects, if given improperly.——This Conſideration made *Boerhaave*, and all other conſiderate Phyſicians, unwilling to give particular Recipes, when they treated of Diſeaſes. This Caution ought therefore to be obſerved with the utmoſt Stricktneſs in the Small Pox, where there is ſo often wanted the the Judgment of the moſt able Phyſician.

monly

monly a *Stool or two* about the *eleventh or twelfth* Day; tho' perhaps they had not one before ſince their firſt Attack *.

This ſhort Account of an inflammatory Fever, and the Small Pox, ſhews us the Neceſſity for a good Phyſician to underſtand, if poſſible, the *Cauſes* of Diſorders, and that his Buſineſs is to aſſiſt and not thwart Nature in her Operations. From hence we may ſee the Reaſon why ſome People are fond of giving hot Medicines in every *Stadium* of the Small Pox, becauſe, ſay they, ſuch a Perſon was recover'd by drinking Wine, Beer, &c. in the Small Pox after he was thought to be irrecoverable. Theſe Inſtances are certainly true; but then, as we ſee ſome Perſons have been kill'd, and others cur'd, in the Small Pox, by one and the ſame Medicine, ſo we are hereby taught that it requires the Judgment of a Phyſician, and not a Nurſe, to know when theſe Things are, or are not proper.

Having ſhew'd that a good Phyſician ſhould be well ſkill'd in *Theory* as well as Practice, I come now to conſider the Animal Oeconomy more particularly. Now, the principal Parts for the Life and Support of the Human Frame ſeem to be agreed on, in the main, by all; and likewiſe to have been ſhewn by a great many convincing Experiments; but their mechanical Uſes are ſo differently deſcribed, by different Authors, that it ſeems the greateſt Difficulty to gueſs which is right, or whether any one is right; each Perſon bringing ſtrong, and ſeemingly convincing Arguments againſt the other's Theory.—Therefore, believing that Nature always acts by the moſt ſimple Means, and that whoever could deſcribe her Actions in the moſt eaſy and ſimple Way ſeem'd the moſt likely to be right upon this Foundation, I have here endeavoured to deſcribe the Uſes of two or three of the moſt principal Parts, which to me ſeem to agree with their Make and Situation in the Human Frame, and alſo with all Experiments that have hitherto been try'd on them; but as the following Theory is ſomething different from what is now generally received, ſo I ſhould not have attempted to offer it to the Publick, did not the whole Practice of Phyſick and Surgery, alſo, ſeem to confirm it; and it always has been my Opinion, and I hope always will be, that it is the Duty of every one to lend their Aſſiſtance towards the Publick Good, let it be ever ſo little; and if what I have here offer'd, be found to be right, I am well ſatisfied, it will be of great Conſequence in the Medicinal Art, and worthy to be enquired into by more able Hands; eſpecially, as I imagine, the meaneſt Capacity will hereby be enabled to underſtand the chief Operations of theſe Parts of the Human Body.

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* This Method of Practice has even exceeded my Expectation; for in *ſeventy-ſix* Patients whom I attended this laſt Year I loſt only *five*; one of whom died the Day after I was ſent for to him, and another was a Child of little more than one Year old, therefore he could not be treated in the manner I could deſire.

Now the Things abſolutely neceſſary to keep the Fluids in Motion, and to move the Parts of the Human Frame, are, from numberleſs Experiments, proved to be

Firſt, " A ſufficient Quantity of Meat and
" Drink taken ſucccceſſively at proper Diſtances
" of Time into the Stomach, by the Exceſs or
" Defect of which, the Fluids will run either
" too faſt, or too ſlowly, and in a ſhort Time
" ſtand ſtill.

Secondly, " The natural Preſſure of the At-
" moſphere."

Therefore, as the Human Frame receives its continual Supply for Encreaſe and Nouriſhment from the Meat and Drink we take into the Stomach; ſo it ſeems moſt natural we ſhould there begin our Enquiry: But in Order the better to underſtand the Cauſes and Method of Digeſtion, I ſhall here add a Note on Fermentation, without which Digeſtion will not be ſo readily underſtood; and this Digreſſion, I hope, will the more eaſily be forgiven as *Fermentation* muſt be allow'd to be an Operation of the utmoſt Conſequence in the Medicinal Art. Therefore, as I imagine, it is an Operation, the Cauſes of which have not already been made clear; ſo I ſhall uſe my Endeavour in aſſiſting to explain it; and if I do not ſucceed I ſhall then be on as good a Footing as many that have miſcarried before me, in the ſame Attempt; but thro' the whole I have taken all poſſible Care to advance nothing but what is confirmed by Experiment.

Of FERMENTATION.

To prove that the Cauſe of Fermentation is not yet diſcover'd or properly explain'd, I think, I need do no more than give you the Sentiments of the great *Boerhaave*, who ſays of it as follows, "Authors, ſays he, have been at a deal of Pains "to deliver an adequate Definition of Fermentation, but with all their Care, they differ "widely from each other; and *not one* of them "affords us an accurate and genuine Deſcription "of the Thing." Here we find *Boerhaave* (who was one of the greateſt Chemiſts and Philoſophers of this Century) tells us that *no one* Philoſopher has yet given a proper *Definition* of the *Cauſes* of Fermentation, and at the ſame Time freely acknowledges, for his own Part, that the Definition he lays down rather deſcribes the *Effect* of Fermentation, than declares its Cauſe.

Now, if by our *Data* in Philoſophy we imagine the acting Parts of this Machine, (the Univerſe) are in the Solids, when in Fact they be in the Fluids, which I ſuppoſe is confirmed by Experiments of all Kinds; it ſeems not at all ſurpriſing that a proper Definition of the Cauſes of Fermentation ſhould not yet have been diſcover'd.—It likewiſe ſeems very probable that when the Operation of *Fermentation* ſhall be better underſtood, ſome Things will then be cleared up, which will be of the greateſt Conſequence to Society; particularly, how the Food in the Stomach is digeſted, how and by what Means the Chyle goes off into the Blood, how and by what

Powers the Circulation of the Blood is carried on, and how the Animal Frame is nouriſhed and ſupported; alſo the Cauſes will then be better underſtood why the Human Frame is ſo ſubject to Fevers and other inflammatory Diſorders, from whence they ariſe, why our preſent Method of Practice is ſo ſucceſsful, and alſo point out to us what other Methods are likely to be of Benefit, and what are not, both in Fevers and other Diſorders incident to the Body.

Fermentation then is deſcribed and allowed to be a gentle, ſlow, inteſtine Motion of the Particles of a heterogeneous Fluid; which is often produced by the Mixture of ſome active Matter or Ferment, which Ferment is generally compoſed of the moſt viſerus and volatile Parts of the Body that have been already fermented, as Yeaſt &c. tho' we find by laying Vegetables, which have been about half dried, in a Heap, in about two or three Days a Fermentation will come on, which will proceed either to Putrefaction, or elſe will break out into an actual Flame.—Therefore it will be proper to conſider.—Firſt, what are the requiſite Things neceſſary to produce Fermentation, likewiſe what promotes and what hinders its Operation. Secondly, How and by what Means Vegetables are ſet on Fire and burnt by a Fermentation of their Parts; and Thirdly, Why at other Times inſtead of producing Fire and Flame a Putrefaction ſucceeds.

Firſt then, the neceſſary Things requiſite to Fermentation are theſe that follow; without either of which Fermentation cannot be carried on.——It is neceſſary that the Place, where Fermentation is produced, ſhould be open and free to the Air; for without Air Fermentation cannot be brought on.—It is alſo neceſſary that the Air be of a proper Temperature; for if it be either too rare, or too denſe, all Fermentation will be ſtopp'd. The Maſs to be fermented muſt be heterogeneous, that is, conſiſt of different Kinds of Matter.—From hence we find that thoſe three Things are requiſite to Fermentation, viz. That the Maſs to be fermented be open and free to the Air, that the Air be neither too denſe nor too rare, and that it be compoſed of Matter of different Kinds. Therefore

As a proper *Temperature of the Air is found to be the acting Agent* in Fermentation, ſo our Enquiry muſt be how and in what Manner the Air acts on the fermenting Maſs.—In order to know this, let us make our Obſervations on the Infuſion of Malt, or what we call *Wort:* It is remark'd by every Body concern'd in Brewing that the *Wort* works *kindeſt and beſt* when the Air is *moderately warm*, i. e. when neither the violent Heat in Summer nor the exceſſive Cold of Winter prevails.—It is alſo obſerved, that the proper Time for mixing the Yeaſt with the Wort, is, when the Wort is neither too hot nor too cold, but about Bloodwarm, more or leſs, according to the Temperature of the outward Air. If the outward Air is cold, then the *Yeaſt* ſhould be mix'd with the Wort, before it is quite ſo cold; and *vice verſâ*, if hot. It is found from Experience that if Brewers neglect this Time, either

their

their Beer works not at all, or if it does it is irregular, in Proportion as they have exceeded or come ſhort of this proper Time. — Having got thus far from Obſervations and Experiments, let us now try to make proper Inferences from them; to aſſiſt us herein we muſt remember that invariable Rule in Hydroſtaticks, viz. *That a Body immerſed in any Fluid, ſpecifically lighter than itſelf, will ſink, otherwiſe it will emerge and get to the Top.* Dr. *Morgan* has certainly gone a great Way towards the Explanation of the *Phænomenon* of Fermentation, and had he known and conſidered by what Means the *Attraction* of the Parts of the Liquor did proceed, I doubt not but he would have given a ſatisfactory Account of the Cauſes of it. — His Principles are theſe, viz. " That the expanſive Force of the Air, ra-" rified by the Action of Fire and Air, is the " *univerſal natural* Cauſe of Fermentation;" he alſo ſays, " There are two great Powers or " Principles in Bodies, viz. an attractive, cohe-" ſive Power, in the ſmall Particles of Matter, " as the Principle of all Reſt, Concretion, &c. " and the expanſive Force of *heated Air, as the* " *Principle of Fermentation.* On the different " Proportion and Adjuſtment of theſe two oppo-" ſite Forces, with reſpect to each other, the " Conſtitution, Texture, and Coheſion of Bodies " are ſaid to depend. — If the attractive Power " prevails, the Quantity of Contact or Degree " of Coheſion will be continually increaſed to a " certain Pitch, where it will reſt: On the con-" trary, if the expanſive Force of the *Fire and*

" *Air*, included in any Body, or Maſs of Matter, prevails againſt the attractive Power of the contiguous Parts, the Parts muſt neceſſarily recede from the Points of Contact: The Receſs of all Parts of Bodies from their Points of Contact, and the Separation and Diviſion conſequent thereon, is what we call *Rarefaction*. As, on the contrary, the Approach of the Parts nearer to the Points of Contact, is called *Condenſation*. Now from the contrary Effects of theſe two Forces, there naturally ariſes an inteſtine Commotion, Colliſion, and *natural Struggle* of the Parts among themſelves, i. e. the Parts acted on by two ſuch oppoſite Forces, will fly off and recoil, recede, and accede, in Proportion to the Strength and Energy of the oppoſite Powers, 'till one or other prevail, either to fix and condenſe, or to diſſolve and diffuſe it; which alternate Motion is what we call Fermentation. — If the attractive Force prevails, the moſt fluid Body will be conſolidated, as Water into Ice.—— On the contrary, if the expanſive Force prevails, the firmeſt Body will be broke and diſſolved."

Here then we find a very exact Enumeration of the Phænomena obſerved in Fermentation; it remains only to ſhew how the *Fire* and *Air* act on each other ſo as to cauſe the *Expanſion* or *Rarefaction*; and from whence the *Attraction* of the Parts of the Body proceed.——The Attraction of the Parts of the fermentable Body may be eaſily ſhewn to proceed from the Preſſure of the Air; for we find that by taking away Part of this Preſſure, by the Air-Pump, a much leſs Degree of Heat will make Water boil, than does in the common Air, and therefore what is called the Attraction of Water or any Liquid, is always in Proportion to the *Denſity*, and conſequently *to the Preſſure* of the Air; as we find any Liquid has a greater Degree of *Attraction*, and will require a greater Degree of Heat to make it boil, in Proportion as the Air in which it is placed has a greater or leſſer Degree of Denſity or Preſſure. — This Preſſure of the Air, I believe, will not be thought inadequate to cauſe not only the Attraction of theſe Fluids, but alſo of all other Bodies; if we do but conſider the almoſt inconceiveable Force that the whole terraqueous Globe ſuſtains. Mr. *Paſchal* computes that every ſquare Foot of Matter on this Earth is conſtringed or bound together by a Force amounting to 2232 Pounds, and every ſquare Inch to upwards of 15 Pounds.——Having found the Cauſe of the Attraction we muſt now enquire from whence the Rarefaction proceeds, which, when we have once found, I imagine, the Phænomenon of Fermentation will be intelligible even to thoſe of a mean Capacity, to thoſe that are little acquainted with Philoſophical Studies.—We find that Expanſion is occaſioned by putting *Yeaſt* to the *Wort* when it is of a proper Heat.—We likewiſe know that this *Yeaſt* conſiſts of a great Quantity of ſubtle, ſpirituous, volatile Particles, wrapp'd up in others of a viſcid Nature; therefore, when theſe ſubtle and volatile Particles come to be put in

Motion by the remaining Heat of the *Wort*, they expand themſelves, and by being ſpecifically lighter than the *Wort*, are forced upward with ſome of the Liquor in which they are entangled, 'till it comes to the Surface of the Liquor, where ſome of its volatile and ſubtle Parts are forced off into the Air, and the Remainder, being then heavier than the Reſt of the *Wort*, is forced downwards, by the Preſſure of the Air.— This inteſtine Motion being once begun it muſt occaſion a Colliſion, Oſcillation, or ſtruggle of the Parts among themſelves; and as I have ſhewn in my Treatiſe on *Electricity*, that any Motion, where there is Air, produces Fire or Light, ſo by this inteſtine Motion more Heat is produced by the Friction of the Air againſt the Parts of the Fluid; and as Mr. *Morgan* has juſtly obſerved, the Parts acted upon by two ſuch oppoſite Forces, will fly off and recoil, recede and accede, in Proportion to the Strength and Energy of the oppoſite Powers, 'till one or the other prevail, either to fix and condenſe, or to diſſolve and diffuſe it. — From hence we may obſerve, that when a Fermentation is brought on, either by throwing a Parcel of half-dried Vegetables in a Heap or otherwiſe, the Fermentation will continue, if every Thing requiſite for Fermentation is there, 'till the Moiſture is ſo far evaporated that the Reſidue breaks out into a Flame, and by that Means entirely diſſolves the Vegetables; or if, on the contrary, the Moiſture prevails, then the Fermentation continues 'till the whole Maſs is diſſolved by Putrefaction.

Having now given an Account of Fermentation, let us return to our Enquiry about the Animal Oeconomy.—The Aliments are taken into the Mouth, where they are cut or bruiſed to Pieces by chewing, mix'd with the *Saliva*, from thence ſent into the Stomach for future Digeſtion.—To me *Hoffman* ſeems to have given the beſt Deſcription of the Nature of the *Saliva*, and alſo in what Manner Digeſtion is carried on, I therefore, ſhall give his Account of it, and then endeavour to make it appear that he is in the right; after which I ſhall go on to the *Circulation of the Blood*, *where and in what*, the Power of that Motion conſiſts, with the Uſe of the Heart and Lungs toward that Motion.

" The Saliva, ſays he, is a thin pellucid Fluid " which doth not concrete by Heat; is almoſt " void of Taſte and Smell, and when agitated " forms a tenacious Froth; it is ſeparated by all " the Glands of the Mouth, and during Hunger " is more copious, fluid, and acrid; after long " Faſting is very acrid, penetrating, detergent, " and ſolvent; it *excites Fermentation* in farinaceous and ſucculent vegetable Subſtances and " Syrups."

" As ſoon as the Aliments have paſſed into " the Stomach, the inferior Muſcle of the " Diaphragm contracts upon the inferior Part of " the Gullet which paſſes thro' it, and thus " cloſes up the Stomach. The Food thus moiſtned, and at the ſame Time *full of Air* depoſited in the cloſe, moiſt, and warm Stomach " according to the different Materials of which

“ it conſiſted; the villous Coat of the Stomach
“ which immediately embraces the alimentary
“ Maſs, ſupplies it perpetually, by innumerable
“ Emiſſaries, with a thin, pellucid, frothy Hu-
“ mour, abounding with Spirits and little Salt,
“ which in moſt voracious Animals is neither
“ alcaline nor acid, but ſomewhat acrid, after
“ long Faſting; and with a more viſcid and mu-
“ cous Humour diſcharged into the Cavity of
“ the Stomach, from certain Glands deſtin'd for
“ that Purpoſe, alſo the Relicts of the former
“ Aliment are mix'd and agitated with it; that
“ the *Air* contained in the alimentary Maſs *ra-*
“ *rifying*, *divides* it intimately; and that the
“ *Heat* of the Part excites and promotes the
“ Actions of all theſe, 'tis evident that the Food
“ muſt in the Stomach be *macerated*, *diluted*,
“ *ſwell'd*, *attenuated*, *fermented*, *and diſſolved*,
“ and thus render'd fit to mix with the animal
“ Juices, and pervade the minute Canals of the
“ Body.” Thus far *Hoffman*.

“ Sometime after the Meat and Drink are in
“ the Stomach, (ſays another Author) its natu-
“ ral Heat joined with the Juices ſecreted out
“ of the Glands, brings on a Fermentation;
“ which increaſes the Heat, rarifies the Air,
“ whereby it expends itſelf, and puts the vo-
“ latile Salts, Air, &c. contained in the Meat
“ and Drink in Motion, the lighteſt Particles
“ flying upwards, and the heavieſt ſubſiding
“ downwards, but by the Motion of the Lungs,
“ Stomach, and Body, the Contents of the Sto-
“ mach are frequently inverted and turned; ſo

"that the lighteſt Corpuſcles are continually "aſpiring and dividing the heavier, and yet con- "tinually turn'd down; and the heavier fix'd "Salts contribute by Friction; 'till by dividing "the Matter infinitely ſmall, make it take up "a greater Space, and by the Buſtle the Cor- "puſcles make in flying this Way and that Way "with great Force, and the Elaſticity of the Air "expand the Fluid in Proportion to the Quan- "tity of the Agents and their Agitation; ſo preſs "ſtrongly againſt the Stomach, which is ſtrong- "ly compreſs'd by the Air without, and hereby "the volatile Matter, as the fineſt and moſt ac- "tive Particles of Air, volatile Salts, and Parti- "cles of Water, Oil, and earthy Matter to which "they adhere, or which they can drive along "with them, preſs into the upper Part of the "Stomach and Guts, and thence into the Lac- "teal Veſſels, where they only find vent in "*Form of Steam*, and by that Force drive the "groſſer Matter which will not pervade them "downwards; and when Digeſtion is once be- "gun, the Diſſolution of the Meat by volatile "Salts, &c. frees more volatile Salts, ſo a freſh "Supply of Steam is continued 'till the Meat is "thoroughly digeſted."

As the Chyle has been obſerved to proceed from the Guts thro' ſome of the moſt minute Veſſels that can be diſcover'd in the Human Frame, and from thence thro' the *Meſenteric* Glands, then to the *Receptaculum Chyli*, and from thence into the Blood at the *Subclavian* Vein or Veins.—As by a great many Obſervations this has been found to be the Method it enters the

Blood, it ſeems a little ſurpriſing, that the Cauſe of this Motion of the Chyle from the Guts into the Blood, ſhould not have been accounted for any otherwiſe, than that it is the fineſt Parts of the Meat and Drink preſs'd out into the Chyle Veſſels as it paſſeth thro' the Guts. — Now, I think, if the Chyle was ſeparated from the Reſt of the Contents in the Guts after the above Manner, which is no more than a ſtraining of the finer Parts, it muſt be vaſtly inſufficient to puſh it thro' the many Paſſages it pervades, before it enters the Blood at the *Subclavian Vein*; and likewiſe if this were the Caſe, the Guts that are generally fulleſt would have the greateſt Number of Lacteal or Chyle Veſſels; whereas on the contrary we find the greateſt Number in the *Jejunum*, which is generally, if not always, found empty after Death; which makes their Diſcovery to be then made with the utmoſt Difficulty; ſo that where Anatomiſts deſire to ſee theſe Lacteals more plainly, they always diſſect ſome living Animal three or four Hours after eating, which ſeems a great Confirmation (amongſt a great many others) that the Chyle paſſeth in *Form of Steam*; for if it paſſed otherwiſe, we ſhould certainly find it after Death as well as before; but if in Form of Steam, then as ſoon as the Animal is dead, it muſt all have either enter'd the Blood or be condenſed into a very ſmall Compaſs *.

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* Dr. *Morgan* has proved in his Mechanical Practice of Phyſick, that " no Subſtances can paſs the Lacteals, recipient " Lymphaticks, but in *Form of a Fluid*, previouſly reduced to " an exceeding fine and imperceptible *Vapour*." See p. 6.

I think we are tolerably certain that, in the Diſſolution of the Meat in the Stomach, there is a Fermentation, and of Conſequence by the Attrition of the aerial Particles there muſt be Heat, which will produce Steam. — I believe it is generally thought that the Parts of any Liquid muſt be very much attenuated, before it is ſent off in Steam; and then the fineſt of its Parts will paſs with the finer Parts of the Air, in that Form, and by that Means enter where otherwiſe that Liquid would not.—That there certainly is Steam in the Blood may be eaſily proved, and ſeen, by looking at Blood juſt let out of a Vein, in cold Weather; and alſo when we ſweat in Bed, by putting out ones Hand and placing it between our Eyes and the Light, from which the Steam may be ſeen to be diſcharged plentifully; likewiſe, we often ſee it diſcharged from the Lungs with our Breath, eſpecially in cold Weather; which Steam can enter the Blood no other Way but by the Lacteal Veſſels, and perhaps not thro' them any otherwiſe but in that Form, and then only when the Guts, and the Mouths of the Lacteal Veſſels, are diſtended by the Steam within the Guts.

It has alſo been ſhewn by numberleſs Experiments, what an unlimited Power rarefied Air, or Steam has; particularly in that ingenious Contrivance, the Fire or Steam-Engine, by which we may ſee, that were it poſſible for the Steam to be confin'd and the Rarefaction to be increaſed by the continual Addition of Fire, it might be made capable of lifting or deſtroying the whole terraqueous Globe, as is often made apparent by the fatal Effects produced by Earthquakes; the Cauſe of which is generally allow'd to be a Sulphurous, or other *Steam* very much rarefied within the Bowels of the Earth.

I think it may eaſily be conceived how the Heat, acting in the Degree it ordinarily does, in the Stomach and Guts, by being confined, may have a Power of not only ſending the Chyle into the Blood, but alſo of ſending the Blood to the extreme Parts of the Body; and we ſee that whenever the Blood is thickned ſo much (let it be from what Cauſe ſoever) as not to be capable of paſſing the ſmall capillary Arteries at the extreme Parts, the Conſequence that follows will be a Fever, from the encreaſed Quantity of Heat or Steam; which is, perhaps, the only Method in Nature whereby theſe Obſtructions can be diſſolved, open'd, and diſcharged; and the preſent Practice of Phyſick in theſe Caſes agrees exactly with what ſeems neceſſary, viz. the leſſening the Quantity by Blood-letting, thereby giving more Room, and by that Means abating the reſiſting Power of the obſtructing Matter, by all ſuch Medicines as moiſten, ſoften, open, dilute, reſolve and cleanſe; as, from Experience we generally find, opening, neutral, ſolvent Medicines to anſwer beſt, with plenty of warm, diluting, aqueous Liquors; by this Method the obſtructing Matter is diſſolved and waſh'd away, the Pores become open, and the general Diſcharge by Perſpiration is again reſtored; ſo the Cauſe of the Fever being removed, the Effects muſt ceaſe.

From what has been ſaid concerning the raiſing the Steam in the Stomach and Guts, and from thence producing the Circulation of the Blood and all the Juices, (if it be true, as it ſeems undeniable to be, and worthy to be farther inquired into) it may be eaſily underſtood how, and in what Manner theſe Operations are carried on, and this with little Trouble and Attention.

Theſe Obſervations, therefore, may be of the more Uſe as at this Time the Practice of Phyſick among the poorer Sort of People is, almoſt, entirely in the Hands of the Apothecaries, ſome of whom have not, *or will not allow themſelves* Time, neither have they Inclination to ſtudy or make themſelves Maſters of the Theory of Phyſick; whilſt others for more ſubſtantial Reaſons, have it not in their Power to underſtand it; ſtill going on in that empiretical Method of giving one Medicine for one Complaint, and another for another, without ever conſulting the Reaſon, or Cauſe of the Diſorder for which the Medicines were given; and as every Body that is a little converſant with Phyſick may eaſily ſee, that one and the ſame Complaint often proceeds from quite oppoſite Cauſes, therefore if the Diſorder be no farther conſider'd, than only as to the Complaints themſelves, which I am afraid is too often the Caſe, they have (in ſome Diſeaſes) juſt an equal Chance whether the Medicine given ſhall do Good or Harm.—As, for Inſtance, a

Delirium may proceed from a Want of a ſufficient Quantity of that ſubtle Steam or Vapour in the Brain for its neceſſary Uſes; which ſometimes happens after lingering Fevers, when the Strength has been greatly exhauſted, and Nature of courſe left low and languid; and it alſo may proceed from its being ſent there in too great a Quantity, which frequently happens upon catching cold; and may ariſe from Repletion of any kind. Now the Conſequence in theſe Caſes will be, that if the Delirium which proceeds from too great a Quantity of Steam, or Vapour collected in the Brain, and the Delirium which proceeds from a Defect of it be treated after one and the ſame Manner; it is obvious to ſee, that the Patient will ſtand a worſe Chance from ſuch injudicious Treatment of the Diſeaſe, than perhaps he might have done, if left entirely to Nature. The ſame Obſervation will hold likewiſe equally true with regard to *Inteſtinal* Complaints; ſeeing it is well known there are different Species of Cholicks ariſing from various and oppoſite Cauſes; and yet the Symptoms in each may in many Reſpects be ſomething ſimilar; ſo that unleſs particular Regard be had to the ſpecific Cauſe of the Diſeaſe, in the Treatment of it, great Danger muſt enſue of courſe.

As Nature always acts with Uniformity, and it is now allow'd, by the niceſt Inquiries into Nature, that there is a great Analogy between Animals and Vegetables; and as Vegetables are nouriſh'd and kept in their Vigor by the ſame Agents, acting in the ſame Manner, ſo it muſt be an additional Argument that the Human Frame is nouriſhed and ſupported, and its Fluids kept in Motion as above deſcribed.

Dr. *Shaw* in one of his Notes on *Boerhaave*, when ſpeaking of the Cauſe of the Riſe of the Sap in Vegetables, gives the following Deſcription of it. See his Chymiſtry, vol. i. pag. 136. "The Juices in Plants, ſays he, are ſuppoſed "to ariſe in capillary Veſſels, *in Form of a ſubtile Vapor*, which being condenſed in the Extremities of the Plant by the Neighbourhood "of cold Air, turns back in Form of Liquor thro' "the more patent Pipes of the inner Bark *". —So, on a proper Enquiry, I doubt not, but we ſhall agree with the above Note, in thinking that the Juices in Plants are raiſed in the ſame Manner he deſcribes, the Vegetables not having the leaſt Power of attracting or ſucking up the Sap, as ſome have imagined, but are quite paſſive; for if the attracting Power lay in the Vegetables, they would at all Seaſons attract in the ſame Manner; but on the contrary, we find they do not, neither can they act but when they are acted upon, as is now (ſince Gardening is ſo much improved) made plainly to appear, for in Winter Time, when the Light or Heat, which proceeds from the Sun, is not of ſufficient Force to drive up the Steam from the Earth, then the Sap of moſt Plants is in little or no Motion; but then, we ſee, that Deficiency may be ſupplied either by Fire, Horſe Litter, or any Thing which by Fermentation has a Power to divide and break to Pieces the Air by *that* inteſtine Motion; and ſo to bring on a Rarefaction, Heat; and by that Means to raiſe a Steam, whereby Plants receive their Supply and Nouriſhment; by which we ſee to a Demonſtration, that the *Heat* (which cannot be produced any otherwiſe but from Fire) and not the Plant, is the acting Principle *.

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* Mr. *Clare*, in his Treatiſe on the Motion of Fluids, ſays, "that *Vegetation is cauſed* (in Part) by the *Sun* in "the Day Time; which not only *attenuates* the Viſcidities "of the Sap, but alſo ſerves to enlarge the Cavities of the "Plant and make it ſhoot."—Hence, in the Night Time, when the Strength of the Sun abates, and the Force below acts with as great a Power as before, the Steam from the Earth is forced up the Veſſels of the Plant. — Hence we ſee the Reaſon why Plants have been obſerved to grow faſter in the Night than in the Day-Time; for the *Sun rarefying and attenuating* the Fluids in the Leaves and upper Parts of the Plants or Trees, and thereby making their Juices more thin and ſubtle, and ſo leſs able to withſtand the acting Force from below.—Thus, as the Power of the Sun abates, the Cold of the Night comes on, condenſes, and thereby brings theſe Fluids, which have been ſo much attenuated, into leſs Space, and by that Means leſſens their expanſive Force, and cauſes a Kind of *Vacuum*, which is immediately ſupplied by the *Steam*, or Vapor which is preſſed into them from below.

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* As ſome People have imagined, by ſeeing Liquids riſe above their Level in capillary Tubes, that the Liquid was drawn upward by ſome unknown attracting Quality of theſe Tubes; ſo, others have thought that Vegetables had a Power to attract or ſuck up Nouriſhment from the Earth, in the ſame Manner; therefore to rectify this erroneous Opinion of theirs, I ſhall produce an Experiment or two of Dr. *Jurin's* which

We likewiſe ſee that Plants may be choaked or ſtrangled in the ſame Manner as Animals ; for

which puts it beyond Doubt.—See *Cole*'s Hydroſtatical Lectures, pag. 231. where there is an Experiment which ſhews, that " a Glaſs Funnel of ſeveral Inches Diameter, having its " ſmall End drawn out into a very fine Tube, which Funnel " being inverted and fill'd with Water, the whole Quantity " of Water therein contained was ſuſtained in the Funnel." —This Experiment proves that the Water was not ſuſtained by the Attraction of the Tube ; for ſuppoſing the Tube to have a Power to attract a ſmall Quantity of Water within itſelf, yet it never was, nor could be thought it had a Power of ſuſtaining ſuch a Quantity.—Pag. 240 is another curious Experiment, viz. that " a Tube open at both Ends, and a " Foot or two in Length, whoſe lower Part is drawn out " into a fine Capillary. This Tube being fill'd with Mer" cury, the whole Column of Quickſilver will be ſuſtained " in it provided the capillary Tube be ſufficiently ſmall. But " if the Mercury in the End be ſuffer'd to touch any other " Mercury, it runs all out of the Tube. If, without letting " it touch any other Mercury, a ſmall Part of the Tube be " broken off, the Mercury will run out, 'till it comes to " ſome leſſer Height, at which it will again ſtop, the Height " being nearly in a reciprocal Proportion to the Diameter " of the ſmall End of the Tube."

From theſe Experiments we learn, that the Riſe and Suſpenſion of Liquids in capillary Tubes, are not occaſioned by any attractive Power in the Tubes themſelves ; but by the Sides of theſe Tubes taking off a Part of the Preſſure of the Air.—For, notwithſtanding the ſuppoſed attracting *Annulus* of the capillary Tube; (which Suppoſition is little better than the old and juſtly exploded funicular Hypotheſis) yet by the firſt Experiment with the Glaſs Funnel, we find, Water was ſuſpended in the Funnel, tho' the Top of the Funnel was of a conſiderable Diameter, and would certainly be the ſame let the Experiment be tryed with a Funnel of any Diameter, provided the ſmall End be drawn out into a capillary Tube. —The laſt Experiment ſhews us, that by filling this Funnel with Mercury, the Mercury remains ſuſpended, unleſs it is made to touch ſome other Mercury.

Theſe

for tho' they have no Lungs, yet they have Parts which anſwer the ſame End and Purpoſe as the Lungs do to Animals, that is, Parts whereby they diſcharge their ſuperfluous Steam: This appears very plain from Obſervation, for a Plant whether it be in a Green-Houſe, or common Hot-Bed Frame, when the Heat is little, and of Conſequence the Steam is raiſed very ſlowly, the Plants diſcharge but very little, and you may

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Theſe Experiments point out to us the juſt Cauſe of Suſpenſion and Aſcenſion of Liquids in capillary Tubes. For, as the Air as well as all other Fluids, preſſes equally every Way, ſo of Conſequence Part of the Preſſure of the Air is taken off by the Sides of the Tube; and if the Diameter of the Tube be ſo ſmall that the lateral Preſſure of the Air on the Top of the Tube counterballances the perpendicular Preſſure, the Liquids will remain ſuſpended in the Funnel. This will always happen if the Orifice of the capillary Tube downwards is ſo ſmall as that a perpendicular Column of Quickſilver is not ſufficient to overcome the lateral Preſſure of the Air; which is every Way equal to a Column of Quickſilver above 29 Inches in Height; which Preſſure is no inconſiderable one; and if we come to conſider impartially, we ſhall not think it inſufficient to perform the above *Phænomena.*

The great and only Objection of any Conſequence is, that the ſame *Phænomenon* happens, with capillary Tubes in an exhauſted Receiver, as there does in the open Air; "therefore (ſay they) the Preſſure of the Air cannot be the "Cauſe of the Aſcent of Liquors in thoſe capillary Tubes, "becauſe this Effect of the Air muſt be wanting in an exhauſted Receiver."——But, let it be remember'd that the Preſſure of the Air is leſſen'd in the capillary Tube, in the ſame Proportion it is on the whole Surface of the Liquid in the Receiver.—And the Action of *Syphons* in *Vacuo* (which is allowed by all to be occaſioned by the Preſſure of the Air) is a clear Demonſtration that the Fluid in an exhauſted Receiver acts in the ſame Manner, as the groſs Air did before it was exhauſted.

keep your Frames or Green-Houſe ſhut for a great while, without any Prejudice to the Plants, but on the contrary, when the Heat is great, and the Steam is raiſed apace, a greater Quantity enters the Plant; and if you don't, at this Time, allow a larger Quantity and greater Freedom of Air, by opening the Houſe or Frames, the Plants are ſoon choak'd and deſtroy'd by their own Steam; this is no more than every common Gardener knows from his own Experience.— We likewiſe find, that Animals are ſmother'd or choak'd in the ſame Manner, viz. for want of a proper Diſcharge of the ſuperfluous Steam from their Lungs. — Animals may alſo be deſtroy'd, if the Atmoſphere or Air wherein they Breath, is not of a ſufficient Denſity to condenſe the Steam coming from the Lungs; as, for Inſtance, in the Receiver of an Air-Pump; tho' the ſuppoſed empty Glaſs is entirely full of *Æther*, or the finer Parts of the Air, which paſſes in at one Part of the Receiver as faſt as it is diſcharged at another, yet Animals ſoon die on the extracting the Heterogeneous and groſs Part of the Atmoſphere, becauſe *Æther*, or the finer Parts of the Air are not a proper Fluid to condenſe the Steam coming from the Lungs of theſe Animals; and for that Reaſon this Steam iſſuing from the Lungs faſter than it can be ſupplied from the Guts thro' the Lacteals and thence into the Blood, and at the ſame Time the Preſſure on the Body of the Animal being greatly abated, the Veins and ſmall Veſſels on the outſide of the Body are extended and fill'd with Blood, whilſt the Arteries and larger Veſſels within are empty: In this Situation it muſt be imagined the Circulation of the Blood muſt ſoon ceaſe, and Death follow.—Hence we ſee the Reaſon why People who have lived in the Country, 'till they are about twenty Years of Age, on their going to *London*, or any other great and populous City, are often affected with a Difficulty of Breathing, Spitting of Blood, &c. which Diſorder proceeds from the Number of Fires kept there, by which Means the Air is ſo thin'd and rarefied, as neither to be of a ſufficient Denſity to condenſe the Steam proceeding from the Lungs, nor to counterballance the Expanſion from within ſo far as to carry on an equal Circulation of the Blood. This Diſorder is often aggravated in *London*, by a free Way of Living. —— This Effect is often found alſo, when the Air is greatly rarefied by Thunder, &c. — The ſame Thing is alſo perceived by thoſe which travel to the Top of high Mountains, " who in Proportion as they aſcend, " find themſelves more and more relax'd ; and " at length fall into a Spitting of Blood, and o- " ther Hæmorrhages by Reaſon of the *Air*'s not " ſufficiently binding up the Veſſels of the Lungs." —This is juſt the ſame as was obſerved of Animals incloſed in the Receiver of an Air-Pump, which, as the Air is taken from them, *ſwell*, *vomit*, *drivel*, *dung*, *ſweat* and *dye*.—All theſe Symptoms are natural Conſequences, when the Preſſure of the Air is inſufficient to counterballance the Expanſion within. — The ſame Symptoms

may

may proceed from a free Way of Living, or by any Thing that encreaſes the inward Expanſion.

From hence knowing the Cauſes of the Diſorder we may find the Things neceſſary for a Cure, to be a cooling agglutinating Method of Living, if it proceeds from an increaſe of the inward Expanſion; but if from the Place you live in, as *London*, or any other great City, the only effectual Care will be to remove to a large Diſtance in the Country.

From hence we may alſo ſee the Reaſon why Fiſh cannot live in our Atmoſphere, out of the Water, viz. becauſe the Fluid of our Atmoſphere is too ſubtle to condenſe the Steam iſſuing from the Lungs of the Fiſh, and the Preſſure on its outward Parts is too little to counterballance the inward Expanſion.

From hence we may likewiſe learn the Reaſon why an Animal uſed to live in our common mix'd Air or Atmoſphere is killed or drown'd by being kept immerſed any conſiderable Time under Water, viz. by the Water, the ſurrounding Fluid being too denſe or heavy for the inward Expanſion; the Steam coming from the Lungs not being of a ſufficient Strength to puſh the Water before it, and thereby to throw off what is ſuperfluous.—Hence all the Veſſels of the Body muſt be ſoon fill'd, and by this Means a Stagnation enſue; add to this, that the Expanſion in the Stomach and Guts, may be often leſſen'd by the cold Water, which is admitted into them. — Hence it is eaſy to learn what are the moſt proper Means to be uſed for the Recovery

in

of an Animal that has been immerſed in Water, if recoverable, viz. by leſſening the Quantity of the Fluids, by Blood-letting; and that by a large Orifice, as ſoon as poſſible; after which, by giving a volatile cordial Medicine to promote an Expanſion within, and raiſe the Steam in the Stomach and Guts apace, a warm Covering, with Frictions all over the Body, blowing into the Lungs now and then with a Pair of Bellows, and thereby expanding them, in order to give a freer Paſſage for the ſuperfluous Steam to get off. —As the Death of Perſons hanged or ſmother'd proceeds from the ſame Cauſe, viz. from an Overfullneſs of the Veſſels, by a Retention of the ſuperfluous Steam, which ought to be diſcharged, ſo the ſame Means ſhould be uſed for their Recovery.

That this Method of Cure, by Accident, has often produced happy Effects on Subjects of this Kind, we have had many and repeated Inſtances, tho' few or none of our Phyſicians have endeavour'd to give us an Account how and by what Means they were brought about; and, I doubt not, but many Perſons have been loſt for want of knowing the proper Methods to be uſed in order to promote their Recovery.

We may carry this Analogy between Animals and Vegetables ſtill farther, and ſuppoſe, with the greateſt Probability, that the ſmall fibrous Roots of Trees and Plants act the ſame Parts to them as the Lacteal Veſſels do to Animals; that is, as in Animals, when the Steam is high in the Stomach and Guts, the Lacteal or Chyle Veſſels are ſoon fill'd by that Steam, and by *that Force* it is ſent into the Blood, thence thro' the Heart, to all the extreme Parts of the Body.—So in Vegetables, as the Steam (which is forced up from below by the Light or Heat proceeding from the Sun, from Fire, from Dung, or any other Fermentation) aſcends, ſome Part of it, that is fine and ſubtle enough to enter the ſmall Canals of theſe Fibres is ſent into them, and from thence into the Stock, and thence into the outermoſt Extremities, and leaves, where a Diſcharge is made of what is more than ſufficient for the Nouriſhment of that Plant or Tree *.

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* That the Nouriſhment of Plants is rais'd in the above-mention'd Manner, and not from an inherent attractive Force, or other occult Quality in the Plants themſelves, cannot well be diſputed, there being ſuch Number of Experiments proving the ſame. This, that curious Obſerver of Nature, Mr. *Hales*, in his vegetable Staticks, (vol. i. p. 63.) has put beyond Doubt, by many convincing Experiments, which prove that the Sun has a great Influence even at two Feet depth under the Surface. After which he Reaſons thus: " Now, ſays he, ſo conſiderable a *Heat* of the *Sun* two Feet " Depth under the Earth's Surface, *muſt needs have a ſtrong* " *Influence in raiſing* the Moiſture at that and greater Depths; " whereby a very great and continual Wreak muſt always " be *aſcending*, during the warm Summer Seaſon, by Night " as well as by Day; for the Heat two Feet Depth is " nearly the ſame Night and Day, the *Impulſe* of the Sun " Beams giving the Moiſture of the Earth a briſk undulating " Motion, which watry Particles when ſeparated and rare" fied by *Heat* do aſcend in the *Form of Vapour*; and the " Vigour of warm and confined Vapour muſt be very con" ſiderable; 'tis therefore probable, that the Roots of Trees " and Plants are thus, by *Means of the Sun's Warmth*, con" ſtantly irrigated with freſh Supplies of Moiſture; which " by the *ſame Means* inſinuates itſelf with *ſome Vigour* into " the Roots." Here Mr. *Hales* gives us an eaſy and natural De-

I think it does not ſeem improbable that the Leaves of Plants are of the ſame Uſe to Plants, as the Lungs are to Animals; for as we ſee in Hyſteric Fits, when the Steam is raiſed very ſlowly, none is perceived to come from the Lungs, by the Mouth, for ſome Time, which ſhews us that no greater Quantity of Steam is carried into the Blood by the Lecteals, than what may be ſent off by the Pores of the Skin; ſo in Winter, when the Steam that is raiſed from the Earth, is very little, the Leaves of moſt Plants, eſpecially in theſe cold Parts of the World, drop off as uſeleſs, and all the ſuperfluous Steam that then enters the Trees is ſent off from their Boughs, which can be but very little; but as ſoon as the Spring advanceth and the Steam is made to riſe more ſtrongly by the additional Heat of the Sun, the Leaf is puſh'd forth; a greater Quantity of ſuperfluous Steam being then neceſſary to be diſcharged, then there was before. What makes this the more probable is, that whenever you *drive* the vegetable Steam into the Tree, either by Fire, or by the Heat proceeding from Fermentation of Horſe-Litter, or any other Way, let it be what Time ſoever of the Year, the Leaf

Deſcription how and by what Means Plants receive their Supplies and Nouriſhment, viz. by the Heat of the Sun *raiſing* the nutritious Moiſture from the Earth, in Form of Vapour or Steam, by which Force (that is, by the Heat of the Sun) it is made to enter the ſmall capillary Roots; which, as was before obſerved, receive their Nouriſhment by the Vapour or Steam riſing from the Earth, in the ſame Manner as Animals do theirs thro' the Lacteals, by the Steam raiſed from the Fermentation of the Meat and Drink in the Inteſtines, is immediately puſh'd forth; and moſt of the Trees which grow near the *Line*, where the Heat is ſufficient to keep the Steam continually riſing, do retain their Leaves all the Year. I have likewiſe obſerved that if you pull off all the Leaves from a Shrub or Tree, when it is in the higheſt Act of Vegetation, it generally dies; if not, it is with the utmoſt Difficulty it can languiſh on 'till the next ſucceeding Spring; which ſhews us, that the Leaves of Trees are of ſome more noble Uſe than only that of Ornament.

Something of this Nature was thought worthy the Obſervation of the Royal Academy at *Paris* in the Year 1707; for they obſerv'd the great Importance of the Leaves towards ripening the Fruit, to which they were ſo neceſſary, that whenever the Caterpillars, as they obſerved, ſeiz'd on a Tree in the Fruit Seaſon, tho' they only deſtroy'd the Leaves; yet the Conſequence here was, that the Tree frequently appear'd as if dead, and the Fruit prov'd abortive.

From what has been ſaid we may find that *Hypocrates* underſtood what were the acting Principles in the Animal Frame better than ſome of our modern Philoſophers; for after telling us that *Heat* was the firſt Principle of all Bodies, he ſays this of the Human Frame. " In ſhort, the
" Fire has diſpoſed every Thing within the Body
" in imitation of the Univerſe?"

" Hence (as another Author obſerves) we find
" the Circulation of the Blood is perform'd by
" two contrary Motions, one going from the
" Heart along the Arteries to the extreme Parts
" of

“ of the Body, Lungs, Externals, and Inteſtines;
“ and the other returning thro’ the Veins to the
“ Heart; which two Motions are performed by
“ two different Agents the one within the Body
“ and the other without.”

“ The firſt Motion is performed by the Steam
“ raiſed out of the Meat, Drink, and Juices in
“ the Stomach and Guts; which as it ferments,
“ rarefies, expands, and iſſues by the joint Force
“ of the Atmoſphere, and its own Expanſion,
“ from the Stomach and Guts, thro’ the Lacteal
“ Veſſels into the *Receptaculum Chyli*, and thence
“ thro’ the Chyle Duct into the *Subclavian* Vein,
“ ſo into the *Vena Cava*, and thence to the right
“ Ventricle of the Heart, hence thro’ the right
“ Ventricle into the Lungs, where the Superfluity
“ is diſcharged, thence thro’ the left Ventricle
“ of the Heart into the great Artery, thence
“ into the leſſer Arteries to the extreme Parts of
“ the Body, and to the Parts which ſerve for
“ Secretion and Diſcharge, where the Remainder
“ of the ſaid Steam is either condenſed or
“ perſpires. (The Neceſſity of which plainly
“ appears, for if the Blood were return’d as hot
“ to the Heart, as it is when it goes from it to
“ the outward Parts, the Heat would be augmented
“ every Time it circulated, and it would
“ be render’d ſo thin, that the Steam would pervade
“ and not circulate it, nor would the Corpuſcles
“ be of proper Figures for Secretion) and
“ of Conſequence the Blood is brought into
“ much leſs Compaſs than when it came firſt
“ from the Heart; and ſo makes a leſs Degree

"of Force neceſſary for the ſecond Agent, which "is the Preſſure of the Atmoſphere, which "forceth the Blood up the ſmall Veins, which "encreaſe in Bulk 'till they come to the upper "or lower Parts of the *Vena Cava*, to the Place "where they unite at the right Auricle of the "Heart, near which the Steam iſſues at the Inoſculation of the Chyle Duct into the *Subclavian Vein*, which is at the upper Part of "the *Vena Cava* near the Heart."

On Enquiring into the Make of the Heart, were we not prejudiced by that common received Opinion, that by its Contraction, it has a Power of ſending the Blood to the extreme Parts of the Body, we ſhould be apt to think that it has as little a Power either of Contraction or Dilatation as a muſcular Part can be ſuppoſed to have; and, perhaps, ſince the Circulation of the Blood has been diſcover'd, not knowing where the Power which circulated it lay, was the Reaſon that Uſes have been aſcribed to ſome Parts of the Animal Frame which do not belong to them; as for Inſtance, aſcribing Motion to the Solids or Muſcles, when from all Experiments we are well aſſured, that they cannot act unleſs they are acted upon by the Fluids which paſs thro' them; and ſome of our lateſt and beſt Anatomiſts ſeem not well ſatisfied with the common receiv'd Opinion, viz. that the Circulation of the Blood proceeded chiefly from the Contraction of the Heart; from whom I ſhall give two ſhort Quotations, with a Deſcription of the Make of the Heart, and ſome Remarks on its Make and Uſe.

Mr. *Cooper* ſays, " that the Heart of an Animal bears a great Analogy to the *Pendulums* of " thoſe artificial *Automata* Clocks and Watches; " while its Motion is perform'd like that of other Muſcles, the Blood doing the Office of a " Pondus;" from which it may be imagined, that he thought the principle Part of its Uſe to be that of a *Stop* or *Regulator*; in the ſame Manner as a Pendulum is to a Clock, and that the Weight, Impulſe, or Cauſe of the Motion was in the Blood itſelf; and it has been wiſh'd, by ſome, that he had explained his Notions more fully.—— Dr. *Keil* allows, " that it is certain " the Force of the Heart is not employ'd in " giving Motion to any Quantity of Blood at " reſt; but only to continue it in its Motion; " and ſays, how that Motion firſt aroſe, ſeems " out of human Capacity to determine." From whence we may infer, that if the Force of the Heart is not employ'd in giving Motion to the Blood at Reſt; its chief Uſe muſt be to regulate that Motion, after the Force, whereby Circulation is carried on, has been given.

Mr. *Winſlow* ſays, the Ventricles of the Heart act the Part of Syringes, in ſucking in the Blood at one Ventricle as it is let out at the other. Now, as it is well known that a Pump or Syringe is quite paſſive, and that the Cauſe of its Action is occaſioned by the incumbent Fluids; ſo we muſt imagine that Mr. *Winſlow* thought the Cauſe of the Action of theſe ſuppoſed Syringes of the Heart, are diſpoſed in a very ſingular Manner,

ſo

ſo as to be capable of making a very great Reſiſtance, but to have little or no Power of Dilatation or Contraction; to prove which I ſhall give a ſhort Abſtract of the Make of the Heart, from *Winſlow*'s Anatomy.—" The fleſhy or muſcular " Fibres of which the Heart (ſays he) is made " up, are diſpoſed in a very ſingular Manner, " eſpecially thoſe of the right or anterior Ven" tricle, being either bent into Arches, or folded " into Angles."

" The Fibres which are folded into Angles " are longer than thoſe which are only bent into " Arches. The Middle of theſe Arches, and " the Angles of the Folds, are turn'd towards " the Apex of the Heart, and the Extremities " of the Fibres, towards the Baſis. Theſe Fi" bres differ not only in Length but in their Di" rections, which are very oblique in all, but " much more ſo in the long or folded Fibres " than in the ſhort ones which are ſimply bent."

" All theſe Fibres, regard being had to their " different Obliquity and Length, are diſpoſed " in ſuch a Manner, as that the longeſt form " partly the moſt external Strata on the convex " Side of the Heart, and partly the moſt internal " on the concave Side; the Middle of the Arches " and the Angles meeting obliquely and ſuc" ceſſively to form the Apex."

" The Fibres ſituated within theſe long ones, " grow gradually ſhorter and ſtreighter all the " Way to the Baſis of the Heart, where they " are very ſhort, and very little incurvated. By " this Diſpoſition the Sides of the Ventricles are

" very thin near the Apex of the Heart, and very " thick towards the Baſis."

" Each Ventricle is compoſed of its proper " diſtinct Fibres; but the left Ventricle has many " more than the right. Where the two Ven- " tricles are joined, they form a Septum which " belongs equally to both."

" There is this likewiſe peculiar to the left " Ventricle, that the Fibres which form the in- " nermoſt Stratum of the concave Side, form the " outermoſt Stratum of the whole convex Side " of the Heart, which conſequently is common " to both Ventricles; ſo that by carefully un- " ravelling all the Fibres of the Heart, we find " it to be made up of two Bags contain'd in a " third."

" All the Fibres are not directed the ſame " Way, though they are all more or leſs obli- " que; for ſome End toward the right Hand, " others toward the left; ſome forward, ſome " backward, and others in the intermediate " Places; ſo that in unravelling them, we find " that they croſs each other gradually, ſome- " times according to the Length of the Heart, " and ſometimes according to its Breadth." Beſides this there are ſmall Bundles of fleſhy Fibres, which come from the Septum to the oppoſite Side of the Ventricle, the Uſe of which Mr. *Keil* ſays is to hinder the Heart from dilating too much.

" The Heart with all the Parts belonging to " it, is contained in a membranous Capſula, " called *Pericardium*, which is in ſome Mea-

“ ſure of a conical Figure, and much bigger
“ than the Heart.”

“ The Pericardium is made up of three La-
“ minæ, the Middle and *chief* of which is com-
“ poſed of very fine tendinous Filaments, cloſely
“ interwoven and croſſing each other in *different*
“ Directions.” — The Space between the Pericardium and the Heart is fill'd with Water.

Therefore, on conſidering carefully the *Make* and *different Directions* of the Fibres of the Heart, the fleſhy Fibres which are found going from the Septum to the oppoſite Side of the Ventricle, the Pericardium and the Water contain'd between them, we ſhall, perhaps, find that it is for a quite different Uſe, than what has generally been aſſigned to it, and then agree with Mr. *Cooper* in thinking it is deſign'd for a *Stop*, or *Regulator* in the ſame Manner as a Pendulum is to a Clock. For, I ſuppoſe, it is out of the Power of a Man to imagine any fleſhy or fibrous Part, leſs capable of Dilatation or Contraction, than the Make of the Heart ſhews it to be; the Fibres croſſing each other in ſo many different Directions, and their different Length, make it capable of very little Dilatation or Contraction any Way whatſoever; therefore it is no Wonder Anatomiſts ſhould differ ſo much, as to the Method, and in what Manner it was contracted; and the reſiſting Power is ſtill encreaſed from the *Pericardium*, which is likewiſe capable of very little Dilatation or Contraction; and the Water in it, which, perhaps, acts the Part of a Medium to defend it from the Preſſure without. And

Experience alſo tells us, that the ſtronger the Contraction of any Muſcle is, when it is cut acroſs its Fibres, with ſo much the greater Violence its Parts will recede from each other.—— Now we ſee, on Tryal, that cut the Heart in what Direction you pleaſe, the Parts recede from each other as little as can be imagined. From hence we muſt conclude, that the Heart has little or no Power to aſſiſt in the Circulation of the Blood, either by its Dilatation or Contraction, but is deſign'd for another Uſe, viz. to be a moſt effectual *Stop* or *Reſervoir* to regulate its Motion; in the ſame Manner as we find moſt, if not all, the Animal Fluids have; as the Gall Bladder for Gall, the Receptaculum Chyli for Chyle, the urinary Bladder for Urine, &c. ſo the Heart for the Blood; which by acting as a Stop or Regulator in the ſame Manner, as a Pendulum does to a Clock; without ſuch a Regulator, the Clock would go on as faſt as can be imagined, 'till it was down or ſome greater Force hinder'd it. So the Blood, without the Heart, would go on in the ſame Manner, 'till the Force which circulates it was taken off, or the Blood Veſſels became quite full.

Perhaps it may be imagined by ſome, that according to the above Deſcription of the Method and Means, by which the Circulation of the Blood is carried on, there is no Account given of the Pulſation of the Heart and Arteries; but on Conſideration it will be found, that the Blood muſt be ſent thro' the Heart and Arteries, by Jumps or Intervals, and returned by the Veins in a ſmooth and regular Stream, for as the Steam iſſues at a ſmall Aperture into the Subclavian Vein, which, as it is continually iſſuing, ſo in a proper Quantity of Time; ſuppoſe a ſecond, its Power encreaſeth ſo much, as to have a Force ſufficient to open the Valve at the right Ventricle of the Heart, which forces the Blood that is there into the Pulmonary Artery, then into the Pulmonary Vein, ſo to the left Ventricle of the Heart, the *Aorta*, and the reſt of the Arteries; and as ſoon as the Force of the Steam is ſo far ſpent, as to be inſufficient to ſend the Blood into the above Parts, the Valves cloſe, and remain ſo, 'till by a freſh Addition of Steam it is made ſufficient to perform the ſame Action over again.—Hence we ſee the Reaſon why volatile Medicines, ſpirituous Liquors, &c. which raiſe Steam apace and fly off very quick, always encreaſe the Pulſation of the Arteries, or as we term it, bring on a Fever. Hence we find the Make of the Parts is ſo contrived, that ſuch a Force is required to circulate the Blood, and when the Steam proceeding from the Meat and Drink, thro' the Lacteals, has acquired ſuch a Strength, it immediately opens the above Paſſages, and ſo takes off the Reſiſtance; by which admirable Contrivance the Steam can never arrive at a much greater Power than what is neceſſary to circulate the Blood; and, it muſt likewiſe be obſerved, that, by this Method the Blood is moved forward in all Arteries of the Body at one and the ſame Inſtant of Time.—As ſoon as the Blood reaches the capillary Arteries, it is from thence (by the Remainder of their Force joined to the Preſſure of the Atmoſphere) ſent into the capillary Veins, and from thence into other Veins ſtill larger and larger 'till it comes to the *Vena Cava*, where it is again mix'd with the Steam, and thereby ſent thro' the Heart as before deſcribed.—As, the return of the Blood to the Heart is from the ſmalleſt Veſſels into thoſe that are ſtill larger till it arrives at the *Vena Cava*, ſo the Pulſation muſt be thereby loſt, and it muſt proceed in a ſmooth equable Stream, and not by Jumps as when it firſt went from the Heart.

The Heat and Colour of the Blood is alſo very differently accounted for by different Authors. "Some aſcribe the Heat to the vital Flame, or "innate Heat of the Heart, ſome to the Mix-"ture of two diſſimilar Fluids, as the Chyle "and Blood, others to an Alcali and Acid; Dr. "*Drake* to the Spring of Air incloſed in the "Veſſels. Dr. *Boerhaave* to the Action of the "Heart and Reaction of the *Aorta*.—They alſo "differ as much as to the Redneſs of the Blood. "Some accounting it to ariſe from the Exalta-"tion of its Sulphur, others from the Mixture "of Saline and Subacid Juices with ſulphurous "Ones; ſome from the Smallneſs of the Size, "and the Roundneſs of the Figure of the Parti-"cles that compoſe the *Cruor*; others from the "Impregnation of Air in the Lungs," (on the Experiment tryed on the Craſſamentum of the Blood, after Blood-letting; for upon turning the under Surface which was before black, upwards, and expoſing it to the Air, it acquires a florid

Colour) which we ſhall ſhew to be impoſſible, from the Anatomical Make of the Lungs, when we come to deſcribe them, with their Uſe. — *Boerhaave* affirms, from the Action of the Heart and Reaction of the *Aorta*.

From the Conſideration of the above Deſcription of the Circulation of the Blood, the Heat and its Colour ſeem more eaſily to be accounted for, than by any other Method I have yet ſeen. Therefore to know the Reaſon of both the Heat and Colour, two Things ſeem neceſſary to be conſider'd.

Firſt, Where that Heat is produced.

Secondly, What it is that produces it.

Firſt, On repeated Tryals and Experiments, we find, that the Blood in the Arteries is always hotter than the Blood in the Veins, and that the Blood is returned to the Heart much cooler, than when it was ſent out. Hence we find that the Heat of the Blood, is kept up or encreaſed in or near the Heart.

Secondly, What it is that produces that Heat, I think, has already been ſhewn to be the Chyle, which is raiſed from the Fermentation of the Meat and Drink in the Stomach and Guts. — And from the Experiments produced on the Riſe of the Sap in Vegetables, it ſeems to be proved that the acting Powers are Air, and a ſufficient Quantity of Light or Heat.

Hence we find that the Heat of the Blood is according to the Rarefaction of the Air, or the Quantity of Light contained in the Blood; which does not enter at the Lungs, as *Borellus* and ſome others have imagined, but is brought into the Blood with the Chyle from the Stomach and Guts, at the *Subclavian* Vein.—Hence we muſt conclude, that any ſort of Matter that cauſes the greateſt Rarefaction in the Stomach and Guts, that breaks and divides the Air moſt and faſteſt, as Volatiles, Spirituous Liquors, Cordials, &c. and then paſs off in Chyle; muſt produce the greateſt Heat in the Blood; and any Thing of an oppoſite Quality the leaſt.

The Reaſon the arterial Blood is hotter than what is contain'd in the Veins, is, becauſe a great deal of the finer Parts of the Blood paſs the Pores in Perſpiration, before it is returned into the Veins.

Hence we find the Heat is always encreaſed when the Pores by which Perſpiration is perform'd are ſtopp'd, (which is commonly the Caſe in hot, dry, burning Fevers) whereby a freſh Addition of Steam being added every Time it paſſes the Heart, it is at laſt made ſo ſubtle as to penetrate its containing Veſſels. Hence are brought on Obſtructions, Mortifications, Death.

Hence we find the Reaſons why the preſent Method of treating Fevers, and other inflammatory Diſorders, which proceed from an over large Quantity of ſubtle Steam in the Blood, is ſo beneficial, and alſo what other Means at any Time, ſeem likely to be advantageous.

From the above Conſiderations we find that the Colour of the Blood proceeds from the ſame Fountain as its Heat, viz. from the Chyle, and what is brought with it into the Blood; for, notwithſtanding the Chyle itſelf is white, yet by mixing with the Blood its Particles are thereby brought to be of a proper Size for a red Colour.

For, as the Colour of Bodies proceeds from the Size of their Pores, and the Make of their Superficies, the moſt compact Bodies, or thoſe whereof the Pores are the ſmalleſt, being always the darkeſt, and thoſe Bodies whoſe Pores and Particles are the largeſt, being of different Colour in Proportion to their Size and Make, 'till we come to thoſe that are quite white; ſo the Colour of the Blood after it is more condenſed, and thereby its Pores made to be ſmaller, when it is returned from the extreme Parts of the Body into the Veins, muſt be of a darker Colour than when it comes to be more rarefied, and its Pores enlarged by a freſh Addition of Chyle, at the *Subclavian* Vein, or Veins, near the Heart. Hence we find this ſubtle Steam, by mixing with the Blood, produces that florid Colour we ſee in the Arterial Blood.—This is confirm'd by viewing the Blood of thoſe People who labour under an Inflammatory Fever, whoſe Blood is always found to be of a very florid Colour. Alſo from that Experiment of turning the under Side of the *Craſſamentum* of the Blood uppermoſt; for at firſt, it will be of a black Colour, but after ſtanding ſome Time, it acquires a bright red, or florid Colour, i. e. after the Air has ſo far operated upon it as to break it to Pieces, and by that Means to enlarge its Pores, and rarefy it. Hence we find that the more rarefied the Air and Steam are, when they enter the Blood, the more florid or lighter will its Colour be, unleſs other Accidents happen which make an Alteration, to the contrary; and the leſs rarefied, the darker; as Experience ſhews us it is.

The Lungs alſo being one of the principal Parts of the Human Frame, and a Part abſolutely neceſſary for Animal Life; as their Uſe ſeems not hitherto to be well underſtood, ſo I ſhall here give a ſhort Deſcription of their Make from the Obſervations of our beſt Anatomiſts, (moſt of which I have abſtracted from Mr. *Winſlow*) and I ſhall then endeavour to ſhew what their Uſe is, and likewiſe in what Manner they perform their neceſſary Actions.——Firſt then, "The Subſtance of the Lungs ſeems to be quite "of a ſpungy Nature made up of an infinite "Number of Membranous Cells, and different "Sorts of Veſſels ſpread amongſt and terminated "by theſe Cells, in innumerable Ramifications. "Theſe Veſſels are reckoned to be Air-Veſſels, "Lymphaticks, and Nerves. The Air-Veſſels "make up the chief Part and are term'd *Bronchia.*—They are lined on the inſide by a very "fine Membrane, which continually diſcharges "a mucilaginous Fluid; and in the Subſtance "of the Membrane are a great Number of ſmall "Blood Veſſels, many longitudinal Lines which "appear to be partly fleſhy and partly made up "of an elaſtic Subſtance of another Kind."

"The *Bronchia* are divided into an infinite "Number of Ramifications which diminiſh gradually in Size; beſides theſe very ſmall Extremities of this numerous Series of Ramifications,

" tions, we find that all the ſubordinate Trunks " from the greateſt to the ſmalleſt, ſend out from " all Sides a vaſt Number of ſhort Capillary " Tubes of the ſame Kind.—Each of theſe numerous " Bronchial Tubes is wider at the Extremity, " and thereby formed into a ſmall membranous " Cell commonly called a Veſicle.

" Theſe Cells or Folliculi, are cloſely connected " together in Bundles, each ſmall Branch producing " a Bundle proportionable to its Extent, " and the Number of its Ramifications."

" Theſe ſmall veſicular or cellulous Bundles, " are termed Lobules; and as the great Branches " are divided into ſmall Rami, ſo the great Lobules " are divided into ſeveral ſmall Ones."

" The Cells or Veſicles of each Lobule have " a Communication with each other, but the " ſeveral Lobules do not communicate ſo readily.

" The Lobules appear to be parted by another " cellulous Subſtance, which is diſperſed " thro' every Part of the Lungs, and forms cellulous " or ſpungy Vaginæ which ſurround the " Ramifications of the Bronchia and Blood Veſſels, " and is afterwards ſpread over the outward " Surface of each Lung; where it forms a Kind " of fine cellulous Coat, joined to the general " Covering of the *Viſcus.*— When we *blow* into " the *interlobular Subſtance*, the *Air compreſſes* " *and flattens* the Lobuli; but when we *blow* " into the *Bronchial Veſſels* they preſently *ſwell.*" This was firſt obſerved by *Helvetius*, and it ſhews us that the Air has a Paſſage from the Blood-Veſſels into the *Bronchia*, but none from the

Bronchia into the Blood-Veſſels; theſe Veſicles when they are extended in Inſpiration, or are blown up, form a Kind of *Valves*, which *hinder* the Air that enters the *Bronchia* from paſſing any farther into the Lungs, unleſs thrown with great Violence; and thereby prevents the ill Conſequences that muſt follow were any of the outward Air to communicate with the Blood; which was a Thing *Borellus* and ſome others imagined.

" The Pulmonary Artery which proceeds " from the right Ventricle of the Heart to the " Lungs, is diſperſed thro' the whole Subſtance " by Ramifications nearly like thoſe of the Bron- " chia, and lying in the ſame Directions."

" The Pulmonary Veins having been diſtri- " buted thro' the Lungs in the ſame Manner, " go out on each Side, by two great Branches " which open into the left Auricle of the Heart. " The Ramifications of theſe two Kinds of Veſ- " ſels in the Lungs, are ſurrounded every where " with the cellular Subſtance already mentioned, " which likewiſe give them a Kind of Vagina. " It muſt be obſerved, that the Ramifications of " the Arteries are more numerous and larger " than thoſe of the Veins, which in all other " Parts of the Body exceed the Arteries both in " Number and Size."

As to the Uſe of the Lungs; the Cauſes generally aſſigned for Reſpiration, are no other than a bare Recital of the Parts affected in it.—Therefore as their Uſes with the Effects thence proceeding, are ſo differently deſcribed by different

Authors; I ſhall give the Opinion of thoſe moſt in Eſteem, and then lay down what I take to be their real Uſe.

Boerhaave thinks "their principle Uſe to be
" for a farther Preparation of the Chyle, and its
" more accurate Mixture with the Blood, and
" by that Means converting it into a nutritious
" Juice proper to repair the Decays of the Body."
But how and in what Manner he does not give us an Account.

Borellus affirms, "that it is for the Admiſſion
" and Mixture of Air with the Blood in the Lungs,
" in Order to form theſe elaſtic Globules it con-
" ſiſts of, and to give it a red and florid Colour."
But how ſuch an Admiſſion can be effected, neither he nor any other Perſon has thought proper to deſcribe; and, as it was before obſerved, the Make of the Lungs ſhews it to be impoſſible.—And its Admiſſion into the Arteries could not be effected were there no Valves to prevent it; for, as the Blood comes directly into the Lungs from the Heart thro' the Pulmonary Artery, with a Force ſuperior to the Preſſure of the outward Air; ſo if a Paſſage were open from them into the Arteries, yet it could not gain the leaſt Admittance.—And the former Account of the Make and Deſcription of the Lungs, ſhews us, that when the Force by which the ſuperfluous Steam proceeding from the Lungs is ſo far abated as not to be ſufficient to withſtand the Preſſure of the outward Air, it is then condenſed and returned along with the Air, 'till it comes to the moſt minute Lobuli of the Lungs, where it is

retarded from going any farther by its proper *Valves*.

It ſeems a little ſurpriſing that ſome great Phyſicians would imagine that the Air ſhould enter and mix with the Blood at the Lungs, when they muſt have often obſerved the fatal Conſequences of cold or groſs Air entering the Blood, at other Places; as, by Perſons after violent Exerciſe, ſitting or ſtanding ſtill in the cold Air, before the Pores have had Time to contract after ſuch Exerciſe, the Air having then a free Paſſage thro' them, (for want of the internal Expanſion or Steam being of a ſufficient Strength to repell it) enters and mixes with the Blood, by which Means Part of the Blood is thicken'd and made unable to paſs the ſmalleſt Veſſels: Hence proceed Obſtructions, Stitches, acute Pains, and the moſt violent Inflammations.—Hence, by knowing the Method and Reaſon why inflammatory Diſorders follow on what we call taking Cold, we may eaſily underſtand what Means ought to be uſed in order to remove them. —Hence we learn how dangerous it is to uſe *empiretical Noſtrums* in theſe Diſorders, which the Vulgar are generally ſo fond of.—Hence we find that the Cauſe of theſe Diſorders are from the cold Air condenſing and thickening the Blood ſo much as to make it incapable of paſſing the ſmall capillary Veſſels.—Hence we ſee the Reaſon why *plethoric*, working People, and thoſe of a ſtrong Habit of Body with rich and thick Blood, are the moſt ſubject to theſe Diſorders, and are generally attack'd with the greateſt Violence.

lence.—Hence we alſo ſee the Reaſon of lowering the Habit of Body in preparing it againſt an Attack of the Small Pox, which is an inflammatory Diſorder, *ſui Generis.*—Hence we may eaſily perceive that the Cure of theſe Diſorders ſhould be undertaken by Bleeding, (and that in a pretty large Quantity if the Patient is plethoric) in order to leſſen the Quantity, which is greatly increaſed by the Heat and Rarefaction. Giving inwardly *large Quantities* of cooling, reſolving, diluting Liquids, joined with laxative Medicines; which Medicines ſhould always be drank a little more than Blood warm. If theſe Medicines ſhould not anſwer the Intention, it is ſometimes neceſſary to join to them Volatiles, and thereby to give them a greater Power to force open and reſolve theſe Obſtructions than they would otherwiſe have *.

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* Not knowing nor underſtanding the Cauſe of Pleuriſies and other inflammatory Diſorders, how often do we find Perſons miſcarry, even under *ſome* who have acquired a Reputation in Phyſick; who on being ſent for, and finding the Patient labouring under a violent Pain in the Side, they directly have recourſe to Bleeding; and this, perhaps, when he is ſinking under his Diſorder; nay, I have ſeen Perſons by repeated Bleedings, (which have often been continued 'till a few Hours before their Death) who, I doubt not, have been as effectually killed, and that without any Relief, as to their Pain, as if they had open'd their *Aorta*, and thereby cauſed them to bleed to Death. But this has been done by thoſe who neither knew the Cauſe of the Diſorder, nor what was the Reaſon why Bleeding has often given Relief in theſe Caſes. Theſe empiretical Gentlemen, like truly knowing Nurſes, on ſeeing it frequently order'd by good Phyſicians, with Succeſs, thence from adminiſter it to all their Patients, without ever conſidering either the State of their Patient or the

It is only the Extremities of the Pulmonary Arteries, and not the Veins which have a Communication into the Veſſels of the Lungs for the Diſcharge of the ſuperfluous Steam; for, as in all other Parts of the Body the Veins exceed the Arteries both in Number and Bigneſs, ſo here, on the contrary, the Arteries are more numerous and large than the Veins.

Sylvius and *Etmuller* ſeem to be much nearer the Truth as to the Uſe of the Lungs, for they take "the great Uſe of Reſpiration to be, by the "Neighbourhood of cold nitrous Air to cool "the Blood, coming reeking hot out of the "right Ventricle of the Heart, thro' the Lungs, "and ſo act as a Refrigeratory."

Dr. *Drake*, with ſome others, lays aſide the

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the *Stadium* of the Diſorder. Now, had they acted from *Anatomy* and *Reaſon*, and thereby have known that this Pain and Inflammation proceeded from *Obſtructions* in the ſmall capillary Arteries, they would have concluded that where theſe Obſtructions are lately formed there great Benefit is to be expected from Bleeding; but on the contrary, to continue it, as is often practiſed, after the Perſon is thoroughly weaken'd by the Continuance of his Diſorder, nothing but the worſt of Conſequences and Death muſt enſue. Therefore when we find that thoſe Diſorders will not give Way (if called in the Beginning) to Bleeding, which ſhould not be adminiſter'd after the Patient is too much weaken'd, and then giving opening, diluting, reſolving Medicines; we muſt endeavour to aſſiſt Nature farther by adding thereto volatile Salts, and thereby giving a Power to theſe Medicines to force open and diſſolve theſe *Obſtructions*. I do not advance this wholly on Theory, but do affirm it with the utmoſt Veracity, that I have practiſed it with ſurpriſing Succeſs on ſome Hundreds of Patients, and don't remember to have met with any it did not relieve, where there was the leaſt Room to expect Succeſs.——But to return.

above Opinion, and, "makes its principal Uſe to
" be to move the Blood from the right Ventricle of the Heart to the Left, and ſo effect
" Circulation, by aſcribing to it the Cauſe of the
" *Diaſtole* of the Heart;" to prove which two Experiments have been brought: Firſt, "That
" after ſtrangling a Pullet ſo as not the leaſt Sign
" of Life appeared, yet by blowing into the
" Lungs thro' the *Trachea*, the Fowl was brought
" to Life again."

Secondly, "That after hanging a Dog, then
" cutting out the Windpipe and tying it to the
" Noſe of a Pair of Bellows, and thus by blowing into the Lungs, he reſtored the Dog to
" Life, and then ceaſing to blow the Dog would
" ſoon fall into dying Fits, but recover again
" by blowing."

Now theſe Experiments do no more than prove, that we are always diſcharging ſuperfluous Steam at the Mouth, from the Lungs, and unleſs this ſuperfluous Steam, (which enters the Blood at the *Subclavian* Vein, and from thence thro' the Heart into the Lungs) is condenſed and diſcharged, it muſt ſoon fill all the Veſſels of the Animal Frame, and of Conſequence ſtop Circulation; and Death muſt enſue, unleſs the Party be timely relieved; the Animal being elſe choak'd with its own Steam; which in a moderate Quantity is the Support and Preſervation of Animal Life. How and in what Manner theſe Animals in this Caſe have been reſtored to Life, has already been deſcrib'd, p. 37, and ſeq.

The Neceſſity of having ſuch a Regulator of the Steam, will appear abſolutely neceſſary, when we conſider what a different Quantity of Steam ariſes at different Times; for we find when we are moſt at reſt, a ſmall Quantity of Steam ariſes, and little is diſcharged from the Lungs, at the Mouth; which, however, is then ſufficient for the neceſſary Uſe of circulating the Blood; but in violent Exerciſe, &c. when the Steam riſes very faſt, the ſuperfluous Steam is diſcharged in great Quantity, at the Mouth, and very quick; which brings it to no greater Quantity than will give room for the Circulation of the Blood.—From hence, we find, the chief Uſe of the Lungs to be for regulating the Steam, that the Blood may receive but a due Quantity to circulate it; for, as we ſee, from the above Experiments, that a little too much ſoon deſtroys the Animal, ſo likewiſe Death muſt enſue from any Quantity leſs than is neceſſary to carry on the Circulation of the Blood.—We alſo find from Experience, that moſt Women and People of a fine Conſtitution, in whom the Steam riſes ſlowly, are often troubled with what are called Hyſteric Fits, where the Perſon will remain ſometimes a great while, even many Hours, without being perceived to breath at all; whilſt the Steam is ſo very little in the continuance of the Fit, as to be hardly able to keep on any Motion in the Blood.

Now, this being a Caſe ſo very plain, we muſt know the Remedies in ſuch Diſorders to be volatile, ſpirituous Medicines, or thoſe that will raiſe Steam ſooneſt and faſteſt, as the whole Practice of Phyſick confirms from Experience.

In ſumming up the chief Particulars obſerved in the former Part of this Eſſay on the Lungs, are theſe, viz. that the Place where the Chyle enters the Blood, in Form of Steam, is in the *Subclavian* Vein or Veins, (for in ſome Subjects it enters only at one of theſe Veins, whilſt in others at both) at a ſmall Diſtance from the Heart; where it enters the right Auricle, and from thence to the right Ventricle, thence by the Pulmonary Artery into the Lungs, which Artery as ſoon as it receives the Blood from the Heart, is diſtributed into Ramifications ſtill ſmaller and ſmaller, 'till they are ſo ſmall that their Apertures by which they enter the Bronchial Veſſels will ſuffer none but the finer Parts of the Blood to paſs in Form of Steam or Breath; where they are joined by the ſmall Ramifications of the Pulmonary Veins, which Veins being much leſs in Number and Size than the Arteries; what is more than ſufficient to fill them, being ſent off by the Paſſages into the Bronchial Veſſels of the Lungs; the Blood is then carried back by them to the left Auricle of the Heart, then thro' the left Ventricle, which is emptied into the *Aorta* or great Artery; and thence diſtributed by the Arteries all over the Body, ſo that the Lungs ſeem to be a Part ſubſervient to that great Member the Heart. Hence we ſee the Reaſon why we breathe ſo much faſter in violent Exerciſe, or when the Steam riſes faſt, than when we ſit ſtill or when the Steam is raiſed ſlowly, for as ſoon as the ſuperfluous Steam is increaſed ſo much, as to have a greater Power, then the Weight of the Atmoſphere; it is ſent out at the Mouth, (which of Conſequence muſt be in much leſs Time when it riſes faſt, than when it riſes ſlow) 'till the Quantity is inſufficient to withſtand that Preſſure; when it is condenſed, and again ſent back into the Lungs; 'till by a freſh Addition of Steam it becomes an Overmatch for the outward Power of the Air.—Hence we find the Neceſſity of this reciprocal Motion, as long as Animal Life remains, and likewiſe why that Motion is performed ſometimes ſo much faſter than it is at others, and that the Lungs ſeem to have little other Uſe in the Circulation of the Blood than to abate the Steam, and thereby bring it to a juſt Quantity for carrying on the Circulation. This alſo ſhews us that there is a larger Quantity of Steam rais'd from the Inteſtines of Animals than can be carried of any other Way, but by the Aſſiſtance of the Lungs; which is the Reaſon that whenever theſe Paſſages of the Lungs are obſtructed, Death muſt enſue.—Hence we perceive the Reaſon why a Child, before it is born, has no Occaſion for Reſpiration, any otherwiſe than what is perform'd by the Mother; and that the Lungs of a Child before it is born are of little or no Uſe; as the Make of the Blood Veſſels of a Child, before it has breath'd ſhews plainly that they are quite different from what they are afterwards. For before the Child is born the Blood has not a Paſſage thro' the Lungs in the above Manner, but is carried a much ſhorter Way; whereas, after a Child has once breathed a Paſſage is required thro' them, to throw off the ſuperfluous Steam, and ſo is naturally open'd accordingly.

FINIS.

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